

Egress Exit Technology Opens in New York City

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Introduction

The emergence of new photoluminescent technologies and groundbreaking changes to the New York City Building Code have combined to set a precedent for providing buildings and facilities with a new benchmark for evacuation safety. Today's safety engineers must be familiar with the principles that are now well established for photoluminescent directional safety way guidance systems so they can incorporate them into new and existing facilities in ways that will provide a higher level of safety for occupants. This presentation will give the background for why this technology was developed and how it has been implemented in New York City.

Background

9/11: Planes hit the World Trade Center's twin towers. In less than 2 hours several thousand people escape. Whether in light or darkness, many survivors credit their lives with the buildings' photoluminescent egress path markings, markings which had been installed for evacuation safety purposes following the 1993 bombing.

Because of 9/11, the New York City Department of Buildings (DOB) convened the World Trade Center Building Code Task Force in March 2002. Its purpose was to recommend ways to amend the building code for improved safety in commercial high-rise structures. This task force issued its recommendations in February 2003 and in June 2004: Local Law 26, containing most of its recommendations, was unanimously approved by the City Council and signed collectively into law by Mayor Bloomberg. The first recommendation to take effect is the mandatory installation of continuous photoluminescent directional egress path marking systems in the stairwells of all Class E commercial buildings 75 feet tall or higher.

Reference Standard 6-1: Photoluminescent Exit Path Markings.

To fulfill Local Law 26 by July 1, 2006, the DOB wrote Reference Standard 6-1.¹ This standard, termed "RS 6-1," is a minimum standard that specifies the physical properties of the materials,

¹ See Local Law 26 of 2004, New York City Building Code § 27-383(b).

size, and placement location of each component. The standard sets forth photoluminescent marking requirements for signs, handrails, steps, and demarcation lines that outline the egress path.

These systems provide essential directional information in the stairwells and transfer corridors under normal lighting conditions. However, their primary function becomes most evident in a power failure and, in particular, if back-up power systems fail. Photoluminescent markings function in darkness and obscurity to give occupants the visual clues they need to find the stairwell entry door and travel along the egress path to the building's final exit.

Material Physical Characteristics

The first section of RS 6-1 specifies the physical characteristics of the photoluminescent materials that can be used to meet the code. Local Law 26 states, "The markings shall be washable, non-toxic, non-radioactive, and if subjected to fire must be self-extinguishing when the flame is removed."²

To satisfy the law, RS 6-1 mandates that photoluminescent products covered by the standard shall be independently tested to certify compliance with the following tests:

- Washability: *ASTM D 4828-1994 (2003), Standard Test Methods for Practical Washability of Organic Coatings.*
- Toxicity: *Bombardier SMP 800-C (Rev. 4, 11/1/2000) Toxic Gas Generation Test.*
- Radioactivity: *ASTM D 3648-2004, Standard Practices for the Measurement of Radioactivity.*
- Flame Spread: *ASTM E 162-2002, Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source or ASTM D 635-2003, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.*

Where outdoor exterior installation conditions exist, or the system will be exposed to unfiltered sunlight, it is recommended that purchasers of the markings choose materials that have passed the following test:

- UV Degradation: *ASTM G 155-2004, Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials.*

Brightness Rating

Perhaps the most interesting physical characteristic to be specified by RS 6-1 is what the standard terms "Brightness Rating" (BR). Photoluminescent materials can absorb optical radiation (light) and then, when the charging light is removed, emit light over a period of time.

² Because of the need for activation lighting to charge the photoluminescent materials, the Department of Buildings eliminated the code's allowance of motion sensor-activated lighting in stairwells.

A landmark study, carried out by the National Research Council of Canada in 1999, proved that the egress speed of people traveling in evacuation conditions in stairwells installed and lit only by photoluminescent markings was at least as good as the speeds in stairwells that had normal lighting at 57 lux or traditional high mounted electrical emergency lighting.³ On 9/11, practically all of the World Trade Center occupants below the impact zones evacuated in less than 2 hours. Because the code was to be written for high-rise buildings, some of which have upwards of 80 floors, the DOB decided to require the use of high-performance photoluminescent materials that use new technology phosphors. Given a 2-foot-candle charge under 4000K-4500K fluorescent lights, these materials can emit light more than 1,000 times brighter than the visual threshold of the dark adapted human eye (.003 milicandela/m²) some 2 hours after their activation source has been removed.

The high-performance photoluminescent materials can be engineered to meet a variety of luminance characteristics. Therefore, the DOB had to specify a test method and a time-base luminance rating that could quantify the material's performance. This luminance rating, coined by the DOB as the material's "Brightness Rating," defines the minimum performance for the photoluminescent materials. The DOB chose *ISO 17398 Safety Colours and Safety Signs — Classification, Performance and Durability of Safety Signs* as the test method to be used by the independent test labs to determine the brightness ratings. The DOB settled on a brightness rating of 30/7/5, which means 30 millicandela/m² output at 10 minutes, 7 at 60 minutes, and 5 at 90 minutes. Though the dark-adapted human eye can detect brightness down to 0.003 millicandela/m², the DOB felt the brightness rating of 30/7/5 would add safety to the installations.

Side Note: In my opinion, though it is easy to be distracted with questions concerning the brightness output of photoluminescent material over an extended period, the more important luminance output values are those concerned with the initial luminance of the photoluminescent material. Why? Because in a power failure two things occur: In the first minutes the human eye will not yet be dark-adapted, so the photoluminescent material must be brightly conspicuous. Second, during a crisis, evacuees need to quickly begin their way out. It is crucial that non-dark-adapted occupants easily locate the door leading to the stairwell and begin their decent while their eyes are adjusting to the dark. Once dark-adapted, the photoluminescent markings specified by the code's minimum brightness ratings will be easily detected for hours. So, though the New York City Code calls for long-lasting phosphorescent materials, the designer of such systems should know the chosen material's initial 2-minute and 5-minute luminance output, because these Exhibits have potentially far greater significance for successful evacuation than the 10-, 60-, and 90-minute values.

Design and Placement Location of Exit Path Markings

In practically all of its component and location requirements, RS 6-1 acknowledges the need to have two standards: one for new buildings constructed pursuant to plans approved after July 1,

³ Assessment of Photoluminescent Material During Office Occupant Evacuation, IR-774, 1999, Guylène Proulx, Ph.D., National Research Council of Canada, Ottawa, Canada; John Creak, Jalite PLC, Wins House, Bentalls, Basildon, Essex, England; Brian Kyle, Public Works and Government Services Canada, Hull, Canada.

2006, and another for those approved prior to July 1, 2006. The DOB recognized the difficulty existing buildings would have installing some of the photoluminescent components defined in RS 6-1. Throughout the code, exceptions or alternative components are defined for existing buildings as compared to new buildings.

RS 6-1 Specifications for Markings on Stairwell Entry Doors.

Local Law 26 limited itself to markings in vertical exit routes (beginning in stairwells and ending at the final exit door). The first components specified are egress signs on or near the stairwell entrance door. RS 6-1 is clear on which doors require markings: “Markings on:

1. Doors opening to ‘exits’ or ‘exit passageways’
2. Doors opening to ‘corridors’ where such ‘corridors’ act as required ‘exit passageways’ connecting two ‘vertical exits’
3. Doors serving as ‘horizontal exits’.” (Such terms are defined in the Building Code of the City of New York.)⁴

RS 6-1 details the placement of the entry door signs as located such that their top edge is no greater than 18 inches from the floor and can be centered or on the handle side of the door. They may also be located on the wall on the latch side of the door, within 6 inches of the door. Door-mounted signs contain the ISO egress symbol and the word EXIT, both at least 4 inches high. Wall-mounted signs contain these two symbols but must also include the ISO arrow oriented in the proper up or down position.



Exhibit 1. ISO 7010 Egress symbols E001 and E002, ISO 7010 Directional arrow E005 and E006.

Because New York City is international, and U.S. standards were being revised to incorporate the ISO symbols for emergency egress,⁵ the DOB decided that all of the signage defined in RS 6-1 would use the ISO symbols for egress contained in *ISO 7010 Graphical symbols — Safety colours and safety signs — Safety signs used in workplaces and public areas - 2003*. Signs placed on the stairwell doors could take one of two forms: the word EXIT along with the ISO 7010 egress symbols E001 or E002 or this same sign but adding the ISO 7010 directional arrow E005 or E006. Signs posted next to the stairwell door are required to have all three elements (the word EXIT, the ISO egress symbol, and the ISO directional arrow). The directional arrow must point the proper direction of the egress path once inside the stairwell door (straight through, down and to the right, down and to the left, up and to the right, or up and to the left - see Exhibit 1 and Exhibit 2).

⁴ NYC Building Code, Reference Standard 6-1 Photoluminescent Exit Path Markings, section 2.1.

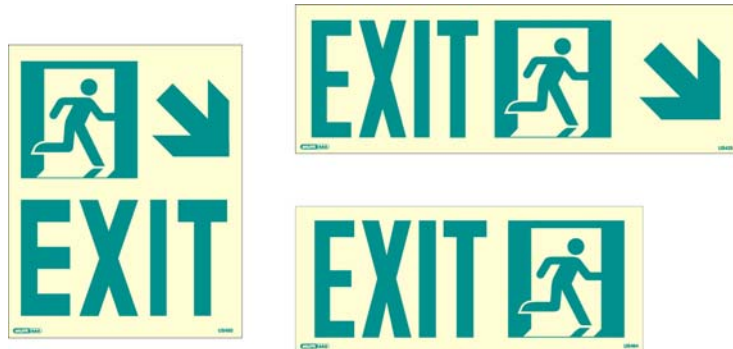


Exhibit 2. Stairwell entrance door signs shown with and without arrows.



Exhibit 3: Stairwell entry doors showing low placement of the photoluminescent emergency exit sign.

RS 6-1 Specifications for Markings on Steps.

Once inside the stairwell, each step needs to be marked. The evacuee should be able to locate the step's leading edge. For new buildings, the entire leading edge of the step will contain a photoluminescent stripe 1 to 2 inches wide and placed within ½ inch from the leading edge (see Exhibit 4). For existing buildings, only the top step of every floor and landing needs to be marked in this way (see Exhibit 5), and the stripe need only extend to within 2 inches from the sides and within 1 inch from the leading edge.

A difference in requirements for new and existing buildings is that instead of marking every step's leading edge, existing buildings may use "L" markers on all but the top steps. The L markers are 1 to 2 inches wide and are to be positioned within 2 inches of the side of the step and within 2-1/4 inches from the back of the step (see Exhibits 4 and 5). The short dimension of the L (its "return") must be no less than 2 inches long on its inside dimension and placed within 1 inch of the step's leading edge.

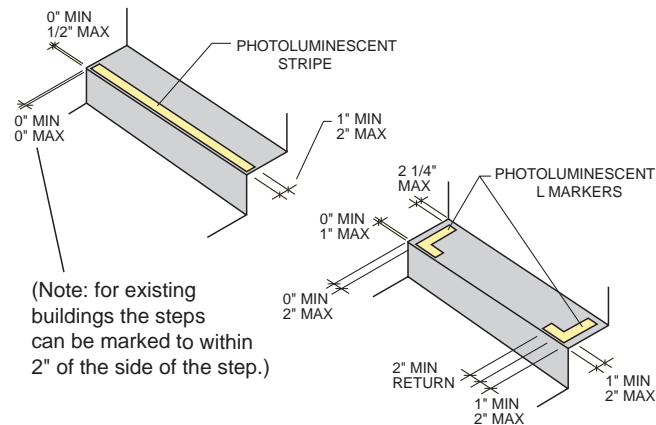


Exhibit 4 Top step marking diagram from RS 6-1 (left), "L" marker location diagram from RS 6-1 (right).

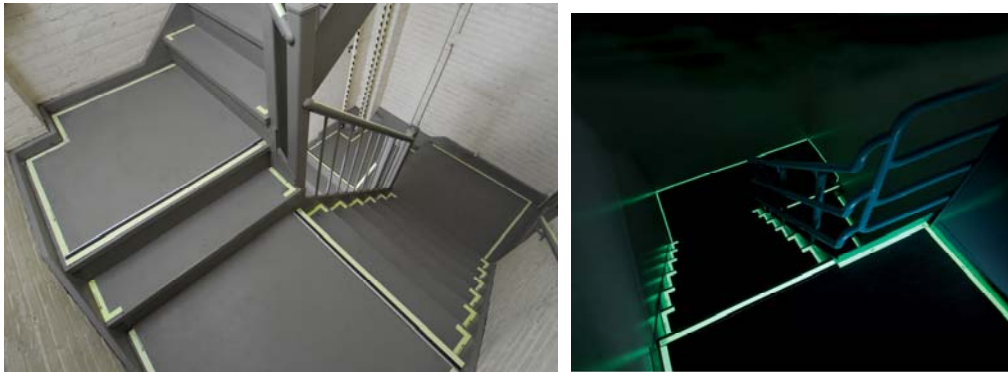


Exhibit 5 Photographs showing RS 6-1 code-compliant components installed, (landing perimeter marking, top step marking, and "L" markers on all subsequent steps).

RS 6-1 Specifications for Markings on Handrails.

For new buildings, a minimum 1-inch-wide photoluminescent stripe shall be placed on the top surface of all handrails (see Exhibit 6). Gaps no greater than 4 inches are allowed in the handrail marking so changes in the angle or direction of the handrail can be accommodated. Because existing buildings have a variety of handrail designs and the condition of the surface on existing handrails could be dubious (e.g. layers of poorly attached paint), the handrail marking is not required for existing buildings. During RS 6-1's public hearing, vehement arguments based on increased safety were put forth by fire-safety professionals and photoluminescent industry experts advocating marking the full length of the handrails for all buildings, new and existing. Because of the added measure of safety they bring, handrail markings are predicted to be chosen for many existing building installations, though not mandated by code.



Exhibit 6 Photograph of an installation showing minimum compliance components for an RS 6-1 new building installation.

RS 6-1 Specifications for Low-Located Demarcation Lines.

The next components defined by RS 6-1 are 1- to 2-inch-wide floor perimeter demarcation lines that are placed on both the inner and outer borders of each stairwell's landings (see Exhibits 5 and 6). If the vertical exit contains transfer corridors, the demarcation lines shall be placed on both sides of the corridor. Where necessary - because of obstructions such as conduits, corners, moldings, or bends - gaps up to 4 inches long can occur in the line. Demarcation lines can be placed either on the wall within 4 inches of the floor, placed on the floor as near as practical to the wall, or a combination of both. The demarcation line should come to within 2 inches of both sides of the top step's leading edge marking. Linking up with the stairs in this way, the demarcation line forms a nearly continuous visual reference point for placing outlining the exit path in the dark.

The demarcation line is to go across all non-exit doors in the egress path, either on the door or on the floor in front of the door. Unless the door is an intermediate exit door or the final exit door, all doors are marked in this fashion. The end result is that if an evacuee crosses over a demarcation line, he or she has left the exit path.

During the RS 6-1 review task force demonstration, the landing demarcation lines were mounted 12 inches above the floor. The result was that with the lights out, people had difficulty sensing the level of the landing. Task force members commented about how they had almost a floating feeling, not knowing where to place their foot after the last step. Lowering the landing's demarcation line to within 4 inches of the floor (closer if possible), eliminates this problem.

RS 6-1 Specifications for Marking Obstacles.

To prevent collision with obstacles in the escape path, all obstacles projecting 4 inches or more into the egress path at or below 6 feet 6 inches high must be outlined with photoluminescent material no less than 1 inch wide. This strip of material shall be comprised of a pattern of alternating equal bands of photoluminescent material and black, with the alternating bands no

more than 2 inches thick and angled at 45 degrees. Examples of such obstacles include standpipes, hose cabinets, wall projections, and restricted height areas, see Exhibit 7. This requirement is for both new and existing buildings.



Exhibit 7 Obstacle tape installed.

RS 6-1 Directional Signage Upon Entering an Exit. Continuous guidance from directional signs helps eliminate hesitation by reinforcing the proper direction of travel for evacuees already in the stairwell, as well as for those entering the stairwell. For new buildings, photoluminescent directional signs consisting of the ISO 7010 egress symbol, ISO 7010 arrow indicating the direction of travel, and, optionally, the word “EXIT,” must be placed inside every entrance into the stairwell, such that they are visible upon opening the door (i.e. the opened door must not obscure the sign). These directional signs (see Exhibit 8) are to be located such that their top edge is within 18 inches above the finished floor. Existing buildings are not required to install these signs for floors above grade, though they are required for all stories below grade.⁵

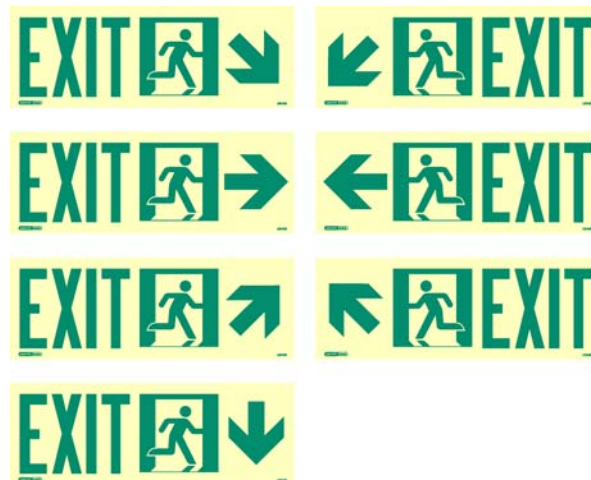


Exhibit 8 Directional egress signs showing correct arrow orientations for each direction.

⁵ Note that the 2006 *NFPA 170 Standard for Fire Safety and Emergency Symbols* includes these exact ISO symbols and defines their proper use in accordance with ISO 3864 and ISO 16069.

RS 6-1 Additional Directional Signage Requirements.

The same type of directional signs as shown in Exhibit 8 must also be used at transfer levels and wherever egress direction changes. Examples of placement include; at turns along horizontal extensions, at transitions from vertical to horizontal direction, and at “T” intersections.

RS 6-1 Signs on Doors That are Not Exits.

Photoluminescent signs shall be placed on doors along the egress path that lead to dead ends (mechanical rooms, storage closets, etc.). Such signs shall contain sans serif lettering at least 1 inch high reading “NOT AN EXIT.” Existing buildings are exempt from this requirement.

From a national standards perspective, I believe that the addition of the NFPA 170 “Not an Exit” symbol (Exhibit 9) is a worthwhile addition to this text message sign. Also note that though the RS 6-1 standard does not contain stipulations to replace the already code-required “Re-entry Door” information signs with photoluminescent versions, in dark conditions this information is essential for evacuees. Many building owners will go the extra step to replace existing re-entry door signs with photoluminescent versions that meet the RS 6-1 material characteristics.



Exhibit 9 Sign for non-exit door using optional NFPA “no exit” symbol.

RS 6-1 Marking of Intermediate Exit Doors and Final Exit Doors.

Some of the most important elements of a directional exit path marking system are the markings on doors that the evacuee must go through in order to safely exit the building. People must:

- Know the door’s location and that they are to go through the door.
- Find the door’s opening mechanism quickly.

When traveling in the egress direction, *intermediate doors* are defined in RS 6-1 as “doors that lead from a vertical exit, horizontal extension in a vertical exit, horizontal exit, supplemental vertical exit, or exit passageway, but do not lead directly to the exterior or to a street level

lobby.”⁶ *Final exit doors* are also defined in this same section of RS 6-1 as “doors leading directly to the exterior or a street level lobby.”

To easily locate the door, RS 6-1 mandates that the top and sides of the door frame of all intermediate and final exit doors must be marked with a solid and continuous 1- to 2-inch-wide stripe of photoluminescent material. Gaps are permitted in the continuity of door frame markings where a line is fitted into a corner or bend, but the gap should be as small as practicable and in no case greater than 1 inch. RS 6-1 goes on to state that if the door molding does not provide enough flat surface on which to locate the stripe, the stripes may be located on the wall surrounding the frame.



Exhibit 10 Final Exit door showing mandatory sign, perimeter marking, pushbar marking, and optional “Push to open” sign.

To prevent hesitation or confusion, RS 6-1 requires that a photoluminescent directional sign as shown in Exhibit 10 appear on the wall adjacent to all intermediate and final exit doors. The final exit door sign must also contain supplemental directional text in sans serif letters half as high as the word EXIT. Examples of such texts are “FINAL EXIT,” “EXIT THROUGH LOBBY,” and “EXIT TO STREET.”

The hardware of all intermediate and final exit doors needs to be marked with no less than 16 square inches of photoluminescent material. This marking must be located behind, immediately adjacent to, or on the door handle and/or escutcheon. Where a panic bar is installed, the photoluminescent material shall be no less than 1 inch (25 mm) wide for the entire length of the actuating bar or touchpad. All hardware markings may include ANSI Z535.1 safety green graphics such as arrows indicating door handle turning directions, the ISO emergency egress symbols, the word “EXIT,” the word “PUSH,” and similar egress-related words or symbols – provided the minimum 16 square inches of photoluminescent material is maintained.

⁶ NYC Building Code, Reference Standard 6-1 Photoluminescent Exit Path Markings, section 2.2.9.

Note that RS 6-1 specifies that the dimensions, distances, and locations of the required markings for all intermediate and final exit doors must be consistent and uniform throughout the route to the building's exterior.

Summary

In October 2005 the 9/11 Commission, chaired by the National Institute for Standards and Technology (NIST), published its final report.⁷ Thirty-two recommendations geared to improving safety in buildings appeared at the end of this report. Number 28 reads:

“Recommendation 18. NIST recommends that egress systems be designed...with consistent layouts, standard signage, and guidance so that systems become intuitive and obvious to building occupants during evacuations....Egress systems should have consistent layouts and standard signage and guidance so that the systems become intuitive and obvious to all building occupants, including visitors, during evacuations.”⁸

In short, what NIST calls for is standardized evacuation signage systems that clearly and consistently demark the layout of egress paths in high rise buildings. Yet these same principles can and should be considered for all facilities; from warehouses to manufacturing plants to office buildings.

New York City's requirements for photoluminescent directional way guidance systems are the first example of the implementation of the NIST recommendations. As such, they set a new bar for safety in the United States. It is expected that similar legislation will mandate these systems for other regions of the country in the near future. It will be interesting to see how architects and manufacturers of high-performance photoluminescent products work together to develop signs and markings that provide a high degree of safety while integrating well into surroundings. These installations will not be limited to emergency egress stairwells in commercial buildings: Residential high-rise buildings, factories, auditoriums, and public spaces are some of the sites where photoluminescent egress path marking systems may soon become the norm.

Bibliography

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New York City Building Code. *Reference Standard 6-1 Photoluminescent exit path markings as required by Local Law 26 of 2004, New York City Building Code § 27-383(b)*, 2004.

⁷ This report can be downloaded from the following URL: wtc.nist.gov/reports_october05.htm

⁸ NIST NCSTAR 1 WTC Investigation, Final Report on the Collapse of the World Trade Center Towers, p. 216-217

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